

REMARKS

Upon entry of this Amendment, claims 3-8, 11, 13, 19-24, 27, 29, and 35-38 are pending in this application. Claims 1, 2, 9-10, 12, 14-18, 25-26, 28, and 30-34 have been cancelled without prejudice and withdrawn from consideration. Claims 37-38 have been added. Support for new claims 37-38 can be found, *inter alia*, in paragraph [0019] of the specification. Claims 3-36 currently stand rejected.

The Office Action of January 11, 2005 has been received and carefully studied. In response thereto, this Amendment is submitted. It is respectfully submitted that, by this Amendment, all bases of rejection and objection are traversed and overcome. Reconsideration is, therefore, respectfully requested.

Claims 5-11, and 14-15 are objected to because of various informalities. Some of the objections are rendered moot due to applicant's cancellation of claims 9-10 and 14-15. With respect to the remaining objections, applicant has entered appropriate corrections in an earnest attempt to overcome the Examiner's objections. Support for these changes can be found throughout the specification, and in particular at paragraph [0019]. It is also noted that claim 11 has been amended to essentially add the subject matter of dependent claim 14 (cancelled herein).

In the Office Action, claims 3-36 currently stand rejected under 35 USC 103(a) as being allegedly unpatentable over WO 43762A1, U.S. 4,138,878 to Holmes et al., U.S. 6,575,662 to French, U.S. 5,855,791 to Hays, and U.S. 4,779,994 to Diller. The rejections are respectfully traversed.

In light of the Office Action, applicant has amended independent claim 3 to better define the invention. Specifically, claim 3 now more clearly defines applicant's method of measuring differential heat flux, in which one of the heat flux sensors is connected to the reference surface, and the other heat flux sensor is connected to the fouling surface. Heat flux values are measured directly from each said sensor in order to calculate differential heat flux data across the heat transfer path. The differential heat flux data is then utilized to detect and quantify deposit

accumulation at the fouling surface. Support for the language of amended claim 3 is found in the specification, *inter alia*, at paragraphs [0015] and [0018].

As defined in amended claim 3, applicant's invention pertains to a method for the measurement of differential heat flux, in which a pair of heat flux sensors are employed to measure heat flux values at a reference and fouling surface, respectively. The heat flux values obtained from the reference and fouling surfaces are then used to calculate differential heat flux data across a heat transfer path between the reference and fouling surfaces. The differential heat flux data is then utilized to detect and quantify deposit accumulation on the fouling surface.

Essentially, the heat flux sensors are effective to obtain two (2) heat flux values simultaneously from the reference and fouling surfaces, respectively. Any difference between the two measured values represents an imbalance between the heat flux values at the reference and fouling surfaces. Such difference is referred to throughout the specification and claims as "differential heat flux". The concept of the present invention is that such differential heat flux is significantly more sensitive to the onset of deposit accumulation than conventional methods based on mere temperature controls and measurement.

As described in applicant's specification, measuring a small differential change in temperature is much more difficult than directly measuring differential changes in heat flux due to a change in heat transfer resistance. This is because the change in heat transfer resistance caused by the accumulation of material deposits may be very small, which means that any difference in temperature (ΔT) will also be very small. However, according to the heat flow equation $\Delta Q = \Delta T / R$, it is understood that the magnitude of the heat flux change (ΔQ) caused by material deposition could be relatively large, even though ΔT is very small. This is because the heat transfer resistance R of the thin film sensors, and the change in heat transfer resistance R caused by the accumulation of material deposits is very small, which means that the magnitude of the differential heat flux measurement ΔQ may be very large. Accordingly, the present invention demonstrates that direct heat flux measurement based on changes in heat transfer resistance is a more suitable method than conventional temperature-based measurements to detect and quantify

deposition. Applicant has shown by experiment that heat flux is significantly more sensitive than temperature to deposition buildup (see Specification, paragraphs [0024]-[0031]).

Turning to items 3 and 4 of the Office Action, claims 3-4, 9-10 and 36 currently stand rejected under 35 U.S.C. 103(a) as being unpatentable over WO in view of Holmes. The rejections are respectfully traversed.

Initially, applicant respectfully submits that the applied references fail to disclose or make obvious a material deposit sensing method as defined in independent claim 3.

I. WO Patent No. 43762A1

Turning first to WO, the patent describes a method and device for detecting the formation of material deposit on a heat flux sensor. The heat flux sensor includes a first surface 4 (i.e., "fouling" surface) in contact with the fluid under test, and a second surface 6 (i.e., "reference" surface) separated from the fluid. Electronics are provided to maintain a constant temperature difference between the first and second surfaces of the sensor so as to generate a single heat flux value representing the absolute heat flux circulating between the first and second surfaces. This single heat flux value is then compared to a reference value to see if it exceeds a predetermined threshold value. If the measured heat flux value exceeds the predetermined threshold value, it is inferred that material deposits have accumulated on the fouling surface 4 of the heat flux sensor (WO Abstract, Claim 1).

Unlike the pair of heat flux values obtained in applicant's invention, WO employs a single heat flux sensor to obtain a single heat flux value. This single measured value is then compared to a predetermined threshold value. If the measured heat flux value exceeds the predetermined threshold value, it is inferred that material deposits have accumulated on the fouling surface 4 of the sensor. In other words, the onset of material deposition is detected only if the measured heat flux value exceeds the predetermined threshold value. This means that small incremental changes which fall below the predetermined threshold value will not be capable of indicating the onset of material deposition. As a consequence, a margin of error is introduced which is dependent on the

range of the predetermined threshold value. This margin of error must be exceeded before the system will be capable of detecting the onset of material deposition, thus substantially reducing the sensitivity of the device.

Furthermore, in sharp contrast to applicant's invention, WO requires the temperature of the second surface 6 to be adjusted in accordance with temperature changes in the fluid so as to maintain a constant temperature difference between the first surface 4 and second surface 6 (Abstract, claim 1). Since the temperature of the WO second surface 6 is adjusted in accordance with temperature changes in the fluid, it is not proper to consider the second surface 6 a constant "reference" surface as that term is used in applicant's claim 3. In applicant's system, the reference surface maintains a constant heat transfer resistance at a given temperature by maintaining the cleanliness of the reference surface, regardless of the heat flux measurement obtained at the fouling surface. Therefore, applicant respectfully submits that WO fails to teach, disclose or suggest a reference surface as that term is used in claim 3.

Based on the foregoing, applicant respectfully submits that WO fails to teach, disclose or suggest a system in which differences between heat flux measurements at a reference and fouling surfaces, i.e., differential heat flux, is utilized to detect and quantify the onset of material deposition as defined in claims 3 and 4.

WO also fails to disclose a method for keeping the reference surface clean by adding a solution to the fluid exiting from the fouling surface as disclosed in applicant's claim 11. As described in the specification, the reference surface of the present invention may be exposed to the same fluid from the fouling side of the sensor, except the chemical composition is slightly modified by on-line addition or generation of acids or chemicals that prevent deposit formation on the reference side of the heat transfer surface (paragraphs [0019]-[0021]).

As discussed above, applicant's system maintains a constant heat transfer resistance at the reference surface at a given temperature by providing a clean reference surface, regardless of the heat flux measurement obtained at the fouling surface. By comparison, it is an essential feature of WO to adjust the temperature on the reference surface 6 so as to maintain a constant temperature

between the first and second layers (i.e., fouling and reference surfaces) of the heat flow sensor (Abstract, claim 1). Such distinction is critical in understanding the nature of applicant's invention. Unlike WO, it is the very difference between the heat flux values obtained at the reference and fouling surfaces that accounts for the differential heat flux data obtained in applicant's invention. Any imbalance between the reference and fouling surfaces will generate a non-zero differential heat flux, which has been found to be more sensitive to the onset and quantity of material deposition on the fouling surface.

Based on the foregoing, it is understood that another essential difference between the present invention and WO is that the present invention does not control or measure temperature. As pointed out in paragraph [0015] of applicant's specification, measuring a small differential change in temperature is much more difficult than directly measuring differential changes in heat flux due to a change in heat transfer resistance. This is because the change in heat transfer resistance caused by the accumulation of material deposit may be very small, which means that any difference in temperature (ΔT) will also be very small. However, according to the heat flow equation $\Delta Q = \Delta T / R$, it is understood that the magnitude of the heat flux change (ΔQ) caused by material deposition could be relatively large, even though ΔT is very small. This is because the heat transfer resistance R of the thin film sensors, and the change in heat transfer resistance R caused by the accumulation of material deposits is very small, which means that the magnitude of the differential heat flux measurement ΔQ may be very large. Therefore, the present invention demonstrates that direct heat flux measurement based on changes in heat transfer resistance is a more suitable method than conventional temperature-based measurements to detect and quantify deposition. Applicant has shown by experiment that heat flux is significantly more sensitive than temperature to deposition buildup (see Specification, paragraphs [0024]-[0031]).

A separate device to maintain a constant temperature difference between the reference surface and the fouling fluid is not required in applicants' invention, thus substantially simplifying the structure compared with conventional methods based on temperature controls and measurement.

Based on the foregoing, applicant respectfully submits that WO fails to teach, disclose or suggest a system in which differences between heat flux measurements at a reference and fouling surfaces, i.e., differential heat flux, is utilized to detect and quantify the onset of material deposition as defined in applicant's invention.

II. Holmes, U.S. Patent No. 6,575,662

Turning now to Holmes, the Examiner correctly notes that Holmes discloses a device and a method in the field of applicants' endeavor. To be sure, both Holmes and applicants' method utilize a well-known thermal bridge concept to measure the onset of deposition in the fluid. However, Holmes differs from applicants' approach in several important respects. First, it is important to note that Holmes is characterized by those skilled in the art as a conventional method for detecting deposition based on traditional temperature (*vis a vis* heat flux) measurement and control. In Holmes, thermocouples are employed to obtain two temperatures θ_t and θ_r at a test and reference surface, respectively. Differences between these temperature measurements ($\theta_t - \theta_r$) are utilized in order to control the thermal bridge (column 25, lines 19-26; claims 6, 7).

In citing to the Holmes patent, the Examiner refers us to column 18, line 10 wherein a feedback signal $\theta_t - \theta_r$ is used to adjust the offset potentiometer 150 until the temperature difference between the test and reference surfaces is made to read zero. In this complicated feedback system, θ_t is the temperature of the test surface and θ_r is the temperature of the reference surface (column 16, lines 52-53; column 18, lines 6-11). Since Holmes uses temperature difference ($\theta_t - \theta_r$) to control the feedback circuit, applicant respectfully submits that Holmes fails to teach or suggest a method for calculating differential heat flux according to the formula $\Delta Q_t = Q_r - C \cdot Q_f$, where Q_r and Q_f stand for heat flux values across the reference and fouling sides of the heat transfer surfaces as recited in claim 4. Based on the foregoing, Holmes does not measure heat flux directly from a pair of heat flux sensors. Instead, heat flux measurements are obtained indirectly through the use of the temperature-based feedback circuit (Figs. 12 and 13; column 25, lines 41-53). Accordingly, withdrawal of the Examiner's rejection of claim 4 is respectfully requested.

In this regard, it appears the Examiner appreciates the characterization of Holmes as a system which uses conventional temperature measurements to control a feedback system to indirectly arrive at a heat flux measurement based on the Examiner's statement in paragraph 4 of the Office Action that Holmes uses the difference in temperature to indirectly represent heat flow / flux

The Examiner also correctly notes that the angular displacement of an output shaft of motor 310 indicates the difference in heat flux required to maintain the temperature difference at the test and reference surfaces (Fig. 13 and column 25, lines 41-61). However, Holmes actually teaches away from using differential heat flux measurements to directly indicate the onset of deposition as disclosed in applicant's invention. In sharp contrast to applicant's invention, Holmes uses absolute heat flux measurements to maintain and control the temperature difference at the test and reference surfaces by way of a complicated feedback circuit. This clearly indicates that Holmes failed to recognize or contemplate the advantages of using differential heat flux measurements between the test and reference surfaces in a direct manner to detect and quantify material deposition as recited in independent claim 3. Accordingly, applicant respectfully submits that Holmes fails to teach or suggest a method for calculating differential heat flux from a pair of heat flux sensors as recited in independent claim 3. Therefore, withdrawal of the Examiner's rejection of applicant's independent claim 3 is respectfully requested.

Additionally, the use in Holmes of a complicated feedback system to indirectly arrive at a heat flux value through temperature measurement is one of the major disadvantages of the prior art which is overcome by applicant's invention. By eliminating a complicated feedback circuit, a separate device to maintain a constant temperature difference between the reference surface and the fouling fluid is not required, thus substantially simplifying the structure. Applicants respectfully submit that, to the best of their knowledge, they are the first to discover that direct heat flux measurement is a more suitable method than temperature-based measurement systems to quantify deposition, and that they are the first to demonstrate that heat flux is significantly more sensitive than temperature to the onset of deposition buildup.

Additionally, neither WO nor Holmes, either alone or in combination, discloses a reference surface in contact with a non-fouling fluid connected to a common heat source as recited in claim 11. In an exemplary embodiment, the reference surface of the present invention is exposed to the same fluid from the fouling side of the sensor, except the chemical composition is slightly modified by on-line addition or generation of acids or chemicals that prevent deposit formation on the reference side of the heat transfer surface.

The Examiner further notes that the temperature difference in Holmes is measured by thermocouples attached to the surfaces, and that heat flux measurement could be indirectly inferred through a complicated temperature-based feedback circuit. However, as mentioned above, applicant's invention eliminates the need for such a complicated feedback circuit, with results being that a separate device to maintain a constant temperature difference between the reference surface and the fouling fluid is not required, thus substantially simplifying the structure. The present invention also recognizes that measuring a small differential change in temperature is much more difficult than directly measuring differential changes in heat flux due to a change in heat transfer resistance. Moreover, it is known that heat flux sensors directly measure the rate and the direction of energy flow, whereas a thermocouple measures temperature. In this regard, it is assumed the Examiner appreciates the advantages of heat flux sensors compared with traditional temperature-based measurements. Such advantages are clearly elaborated in U.S. Patent 4,779,994 to Diller as cited by the Examiner in this Office Action.

Based on the foregoing, applicant respectfully submits that a patentable invention may lie in the discovery of the source of a problem. In the present case, the applicant's recognition that differential heat flux measurements are significantly more sensitive than conventional temperature-based measurements in detecting the onset of material deposition is part of the subject matter of applicant's invention, and should always be considered in determining the non-obviousness of an invention under 35 U.S.C. 103 [see *In re Sponnoble*, 405 F.2d 578, 585, 160 USPQ 237, 243 (CCPA 1969)]. Accordingly, it is submitted that the applicants' invention as set forth in claims 3-

4 and 36 is not taught, anticipated, or rendered obvious by Holmes for all the above reasons, including the reasons discussed previously in conjunction with the WO reference.

Upon careful consideration, applicant respectfully submits that applicant's claims are patentably distinct over the applied references. Accordingly, it is respectfully requested that the Examiner's rejection of applicant's claims 3-4 and 36 be reconsidered and withdrawn.

Turning now to item 5 of the Office Action, claims 5-8 and 11-18 also stand rejected under 35 USC 103(a) for the reasons contested above in further view of U.S. Patent 6,575,662 to French. As noted above, claims 9-10, 12 and 14-18 have been cancelled. Claims 5-8, 11 and 13 all depend, in one way or another, from independent claim 3, and therefore contain all the limitations found therein. By this dependency, it is submitted that the applicants' invention as set forth in claims 5-8, 11 and 13 is not taught, anticipated, or rendered obvious for the reasons discussed previously in conjunction with claims 3 and 4.

Claims 19-34 also stand rejected under 35 USC 103(a) for the reasons contested above in further view of U.S. Patent 5,855,791 to Hays et al. As noted above, claims 25-26, 28 and 30-34 have been cancelled. Claims 19-24, 27 and 29 all depend, in one way or another, from independent claim 3, and therefore contain all the limitations found therein. By this dependency, it is submitted that the applicants' invention as set forth in claims 19-24, 27 and 29 is not taught, anticipated, or rendered obvious for the reasons discussed previously in conjunction with independent claim 3.

Claim 35 also stands rejected under 35 USC 103(a) for the reasons contested above in further view of U.S. Patent 4,779,994 to Diller et al. (hereinafter "Diller"). Claim 35 depends from independent claim 3 to contain all the limitations found therein. By this dependency, it is submitted that the applicants' invention as set forth in claim 35 is not taught, anticipated, or rendered obvious for the reasons discussed previously. As mentioned above, it is believed the Examiner appreciates the advantages of heat flux sensors compared with traditional temperature-based measurements as clearly elaborated Diller. However, applicant respectfully submits that Diller simply fails to provide any hint or suggestion that the use of an improved heat flux sensor as

disclosed in Diller would solve the problem of early detection of deposit accumulation in fluid transfer vessels. Nowhere does Diller provide any hint or suggestion that differential heat flux measurements obtained from a pair of heat flux sensors could be used to more effectively indicate the early onset of deposit accumulation.

In the present case, applicant's recognition that differential heat flux measurements are significantly more sensitive than conventional temperature-based measurements in detecting the onset of material deposition is part of the subject matter of applicant's invention, and should always be considered in determining the non-obviousness of an invention under 35 U.S.C. 103. *In re Sponnoble*, 405 F.2d 578, 585, 160 USPQ 237, 243 (CCPA 1969).

In summary, analysis has been presented as to why the applicants' invention is not taught, anticipated, or rendered obvious by references cited by the Examiner. Careful review of the cited references clearly shows that persons having ordinary skill in the art have not been able to fully exploit the advantages of using differential heat flux data to detect and quantify the onset of deposit accumulation. In view of the prior art in its entirety, it would not be obvious to one of ordinary skill in the art to discover that differential heat flux data would be more sensitive to deposition buildup compared to conventional temperature-based measurement systems, or that the complex feedback structure of conventional temperature-based measurement systems could be eliminated by employing a pair of heat flux sensors to arrive at a differential heat flux measurement to indicate the onset of deposition accumulation as claimed in applicants' invention.

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For all of the above reasons, it is respectfully submitted that upon consideration of this amendment, all solicited claims will be deemed to define patentable subject matter. Accordingly, the prompt issuance of a Notice of Allowance is respectfully solicited.

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Should the Examiner have any questions or comments regarding this application which may be resolved by a telephone interview, the Examiner is respectfully requested to contact the undersigned at the telephone number below.

Respectfully submitted,

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